Residential Water Heating Hourly Calculations

Charles Eley, FAIA, PE
Eley Associates

Benefits

- Simplicity
- Consistency
- Accuracy
- Closes Loopholes
- Assesses Peak Loads
- Needed for TDV

Relationship to Other Measures

- Time Dependent Valuation
- Code Change Proposal for Multifamily Water Heating
- Water Heating Distribution Systems

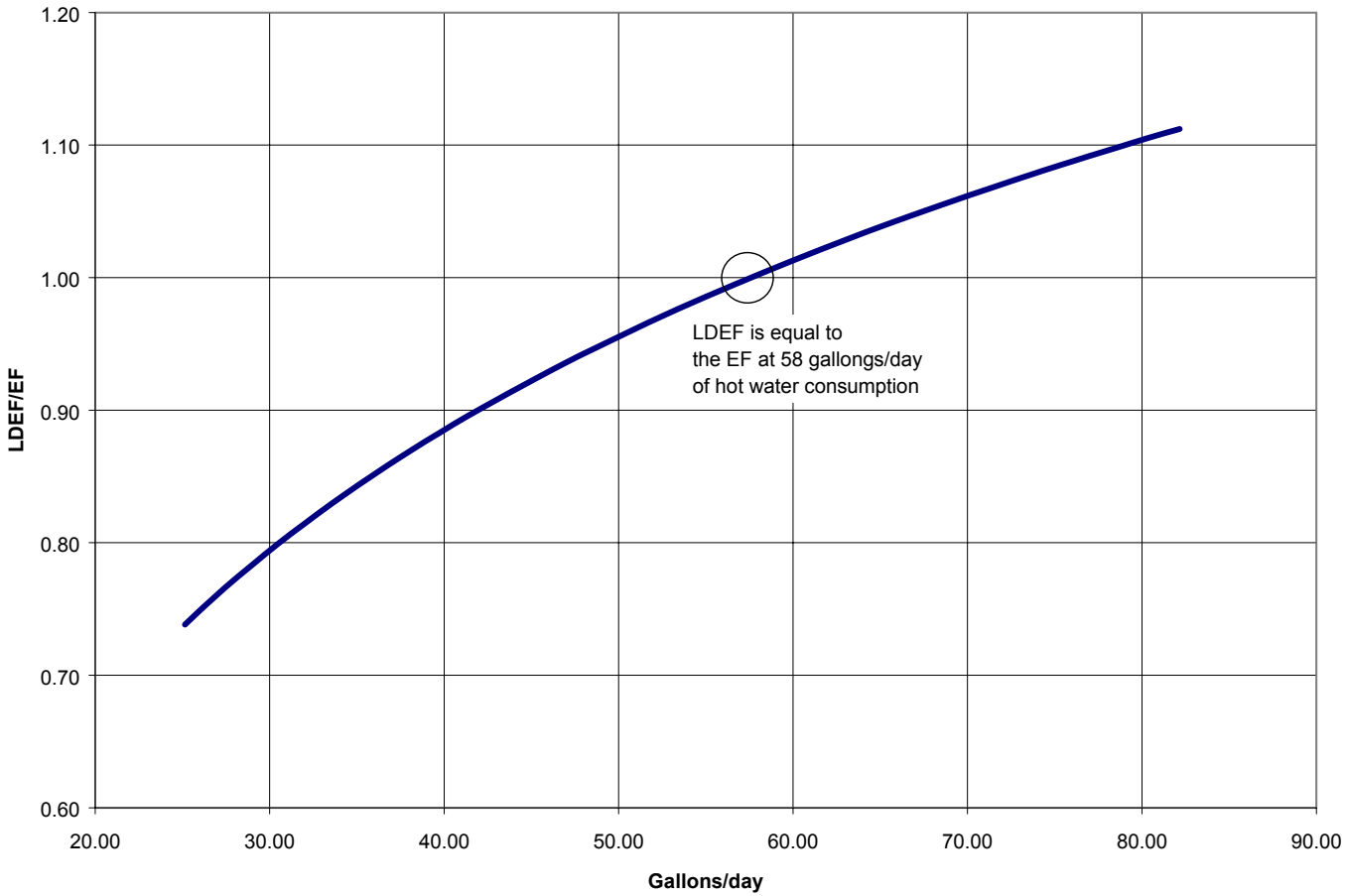
Goals

- Must work with TDV
- Consistent with current modeling assumptions
- Accommodate proposed definitions of standard design water heating systems for systems serving individual units and multiple units.
- Implements the revised distribution loss procedures.

Steps in the Process

- Modify the LDEF calculation method to work on an hourly basis
- Modify the calculation procedures to result in an hourly adjusted recovery load (HARL)
  - Implement the recommended distribution system credits
  - Adopt an hourly schedule of hot water use that is consistent with the current modeling assumptions
  - Define other inputs such as the temperature rise between the inlet and supply
- Define the standard design water heating systems

Modifying the LDEF



Modifying the LDEF Method

$$LDEF_j = \ln\left(\frac{ARL_j \times 1000}{365}\right)(a \times EF_j + b) + (c \times EF_j + d)$$

Equation 1

$$WHEU_j = \frac{ARL_j}{LDEF_j}$$

Equation 2

$$\frac{ARL \times 1000}{365} = \frac{HARL \times 24}{1000}$$

Hourly Modification

Equation 3

$$LDEF_j = \ln\left(\frac{HARL_j \times 24}{1000}\right)(a \times EF_j + b) + (c \times EF_j + d)$$

Equation 4

Adjusted Recovery Load (ARL) – Existing

$$ARL_K = SRL_k \times DSM_K$$

Equation 5

Equation 6

$$SRL_k = \sum_{i=1}^{n} \frac{0.0855347\left(\frac{CFA_i}{1000}\right)^2 + 3.61307\left(\frac{CFA_i}{1000}\right) + 6.036}{NmbrSys_i}$$

Hourly Adjusted Recovery Load (HARL) – Proposed

$$HARL_K = HSEU_K \times DLM_K$$ Equation 7

$$HSEU_K = (GPH_k \times 8.3 \times \Delta T)$$ Equation 8

$$DLM_K = 1 + ((SDLM_K - 1) \times DSM_K)$$ Equation 9

$$SDLM_K = 1 + 0.074 + 0.00010 \times CFA$$ Equation 10

$$SDLM_K = 1 - 0.007 + 0.00008 \times CFA$$ Equation 11

Load Dependent Energy Factor (LDEF) Coefficients

Coefficient	Storage Gas	Storage Electric	Heat Pump
A	-0.098311	-0.91263	0.44189
B	0.240182	0.94278	-0.28361
C	1.356491	4.31687	-0.71673
D	-0.872446	-3.42732	1.13480

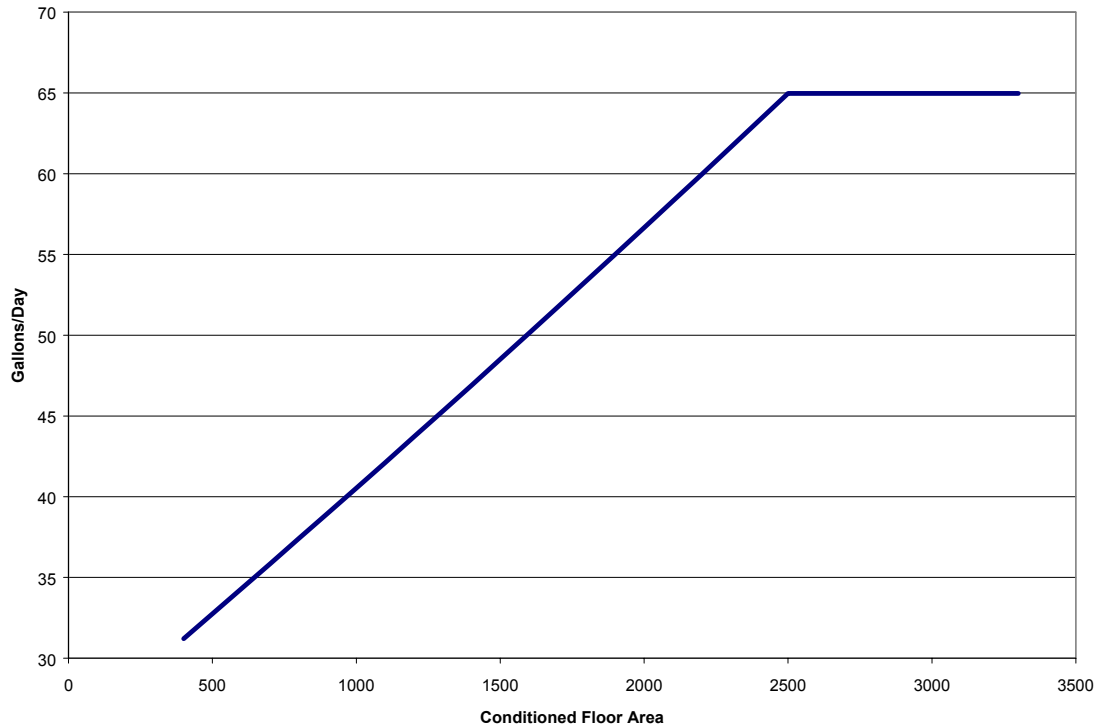
Proposed Distribution System Multipliers

Distribution System Measure	Code	Systems Serving Individual Units: Mandatory Kitchen Pipe Insulation	Systems Serving Individual Units: Basecase is Standard Main and Branch	Systems Serving Multiple Units
Pipe Insulation (all lines)	PIA	0.92	0.73	n. a.
Pipe Insulation (kitchen lines)	PIK	1.00	0.79	n. a.
Point of Use	POU	0.00	0.00	0.00
Parallel Piping	PP	1.09	0.88	1.09 or 0.88
Recirculation (no control)	RNC	4.81	3.80	TO BE PROVIDED
Recirculation + timer control	RTm	3.22	2.54	TO BE PROVIDED
Recirculation + temperature control	RTmp	3.97	3.14	TO BE PROVIDED
Recirculation + timer/temperature	RTmTmp	2.65	2.09	TO BE PROVIDED
Recirculation + demand control	RDmd	1.39	1.10	TO BE PROVIDED

Average Daily Hot Water Consumption

$$GPD = 24 + 0.016 \times CFA$$

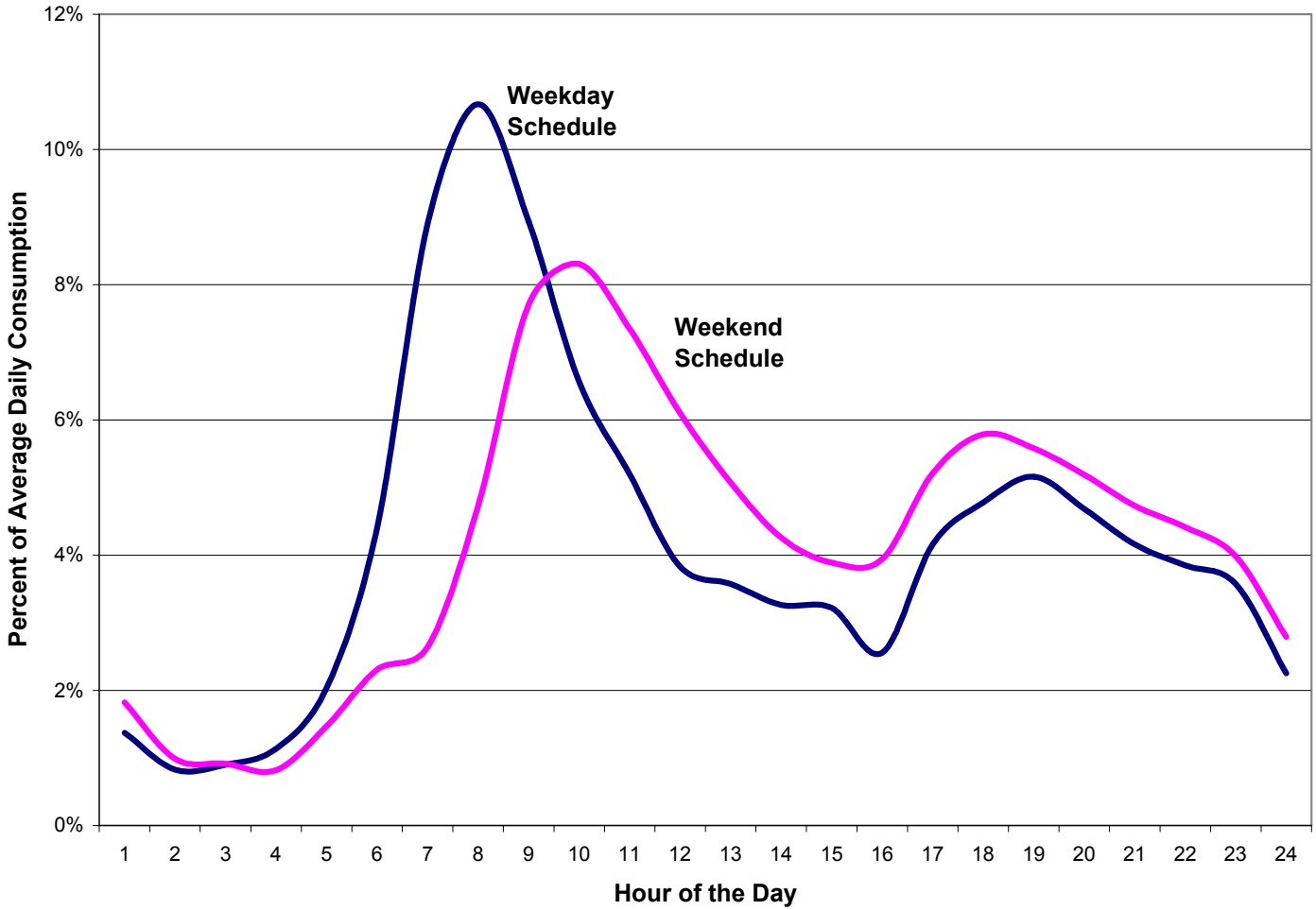
Equation 12



Inlet Temperature

Climate Zone	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	52.2	51.5	51.4	51.8	53.1	54.5	55.6	56.4	56.4	55.8	54.7	53.4
2	53.3	51.5	51.4	52.2	55.6	58.9	61.8	63.6	63.8	62.3	59.5	56.3
3	55.1	54.1	54.0	54.5	56.5	58.5	60.3	61.4	61.5	60.6	58.9	56.9
4	55.5	54.0	53.9	54.6	57.5	60.3	62.8	64.3	64.5	63.2	60.8	58.0
5	55.7	54.8	54.7	55.2	56.9	58.7	60.2	61.1	61.2	60.4	59.0	57.3
6	59.1	58.1	58.0	58.5	60.4	62.4	64.0	65.1	65.2	64.3	62.7	60.8
7	60.1	59.1	59.0	59.5	61.5	63.4	65.2	66.2	66.3	65.5	63.8	61.9
8	60.0	58.8	58.7	59.2	61.6	63.9	66.0	67.3	67.4	66.3	64.3	62.1
9	60.5	59.1	59.0	59.7	62.2	64.8	67.1	68.5	68.6	67.5	65.3	62.8
10	59.4	57.6	57.4	58.3	61.8	65.2	68.2	70.1	70.2	68.7	65.8	62.4
11	54.9	52.4	52.2	53.4	58.2	63.0	67.2	69.8	70.0	67.9	63.8	59.2
12	54.6	52.5	52.3	53.3	57.3	61.3	64.8	67.0	67.2	65.4	62.0	58.1
13	57.5	54.7	54.5	55.8	61.0	66.2	70.6	73.5	73.7	71.4	67.0	62.0
14	54.2	51.2	51.0	52.4	58.2	63.9	68.8	72.0	72.2	69.7	64.8	59.3
15	66.8	64.0	63.8	65.1	70.4	75.8	80.4	83.3	83.6	81.2	76.7	71.5
16	44.4	41.8	41.6	42.8	47.7	52.6	56.8	59.5	59.7	57.5	53.4	48.7

Hourly Schedules



Southern California Gas Company
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Codes & Standards Project

Standard Water Heating Systems Serving Multiple Dwelling Units

- central recirculating water heating system shall be installed with a single water heater that meets the minimum efficiency requirements of Section 113
- distribution system controls capable of automatically turning off the circulating pump when hot water is not required.
- Distribution system piping shall be insulated

Standard Water Heating Systems Serving Individual Dwelling Units

- gas storage water heater in minimum compliance with the NAECA requirements.
- The size and EF of the standard design varies with the size of the water heater proposed for the proposed building.
- The standard system has a standard distribution system as defined above and in the Davis Energy Group research.

Example Calculations

Hour	Hourly Schedule	Hourly Adjusted Recovery Load (Btu)	Load Dependent Energy Factor (LDEF)	Water Heater Energy Use (WHEU)
1	0.013	501	0.37	1355
2	0.009	358	0.31	1161
3	0.009	358	0.31	1161
4	0.011	429	0.34	1257
5	0.021	787	0.45	1739
6	0.045	1718	0.60	2884
7	0.093	3578	0.73	4902
8	0.103	3936	0.75	5266
9	0.090	3435	0.72	4755
10	0.071	2719	0.68	4001
11	0.052	2004	0.62	3213
12	0.039	1503	0.57	2632
13	0.035	1360	0.55	2460
14	0.034	1288	0.54	2373
15	0.030	1145	0.52	2197
16	0.022	859	0.47	1833
17	0.043	1646	0.59	2801
18	0.047	1789	0.60	2967
19	0.049	1861	0.61	3050
20	0.045	1718	0.60	2884
21	0.043	1646	0.59	2801
22	0.041	1574	0.58	2717
23	0.035	1360	0.55	2460
24	0.021	787	0.45	1739
Total	1.000	38358	n.a.	64608